The Use of the Starrett Transit

STARRETT TOOLS

STARRETT HACK SAWS CUT QUICKER LAST LONGER

The Use of the Starrett Transit

A Booklet to accompany the Starrett Transit and Level—simple, inexpensive instruments for the farmer, contractor and builder.

An explanation of a few typical problems in laying out and leveling, which will enable the inexperienced man to solve every-day problems connected with his work.

COMPLIMENTS OF

THE L. S. STARRETT COMPANY

World's Greatest Tool Makers

MANUFACTURERS OF HACKSAWS UNEXCELLED
STEEL TAPES—STANDARD FOR ACCURACY

ATHOL, MASS., U. S. A.

NEW YORK LONDON CHICAGO

THE USE OF THE STARRETT TRANSIT OR LEVEL

THESE instruments have been made for those farmers, contractors and builders who do not care to invest in an expensive engineer's instrument, or who have not had sufficient experience or sufficient training in mathematics to use the engineer's transit with its refined measurements. In price, the Starrett instruments are within the reach of anyone who has to do a sufficient amount of measuring and leveling, and because of their simplicity and freedom from complications they can be used by anyone who is willing to exercise ordinary care. In general, it may be said that the Starrett transit or level can be used for the same purposes as any engineer's transit and level, that is, for determining the amount of fall in locating drains, finding the height of springs, laying out foundations for buildings, and in the building of dams and race-ways for simple water-power developments.

If the bearings of the lines are not required, these simple instruments will be found superior to the ordinary needle compass in taking angles in those

places where, because of local attraction, they cannot be set off with the needle.

The farmer finds continual use for this instrument in laying out his fields when planning crop rotations, planting orchards, and similar work. In conjunction with neighbors he uses the transit for laying out roads and side ditches, thereby insuring proper grade for drainage.

The transit is especially valuable to the farmer in connection with laying out of tile drainage or irrigation systems where the grade must be known in order to properly lay out the system. For highest efficiency the drain should have a uniform grade or series of grades from head to outlet. Because of the uneven surface of much of the land to be drained, it is more likely to be a series of drains than one uniform slope from top to bottom. This is preferable because it keeps the line of tile at a more uniform distance below the level of the soil. There are many cases where, if a uniform grade were followed from head to outlet, the tile line would either run out of the ground in places or be buried so deeply in other places that its drainage effect would be small, aside from being a means of carrying off the water collected from portions of the field where the tile came close enough to the surface to collect water from the top soil.

The builder or contractor uses the transit in

laying out foundations, locating batter boards, and leveling for grading and also in the pouring of monolithic concrete floors.

Millwrights and machinists may use the Starrett level to advantage in leveling and aligning shafting in a mill or factory.

The Starrett transit (see page 28) combines in one instrument the facilities for measuring both horizontal and vertical angles, thus enabling the operator to lay out anything that does not require excessive refinement. The level (see page 27) is for measuring angles in a horizontal plane only. While this booklet will describe the uses of the transit, it should be borne in mind that the level will do all that a transit will, except measure vertical angles.

To illustrate some of the uses to which this instrument can be put, a few examples will be given, both on leveling and on laying out foundations, etc. When using the instrument the legs must be firmly set into the ground so that neither the wind nor an accidental touch will disturb the adjustment. The instrument should then be made as nearly level as possible by adjusting the lower parts of the extension legs. It should then be brought to a perfect level by the use of the leveling screws between the plate and tripod head. This is done by bringing the level over any one of the leveling screws and turning one screw

in and another out until the bubble appears in the center of the level glass. Then turn the sight tube or telescope through an angle of about 90° and again adjust the bubble to the center of the glass by means of two leveling screws. This operation should be continued until the bubble stands in the center of the glass, no matter what direction the level may be turned.

To Find Difference of Level of Two Places.

When the two places are visible one from the other and do not differ in level more than 10 or 12 feet, the instrument should be placed in some position as at C, Fig. 1, about equally distant from the two points

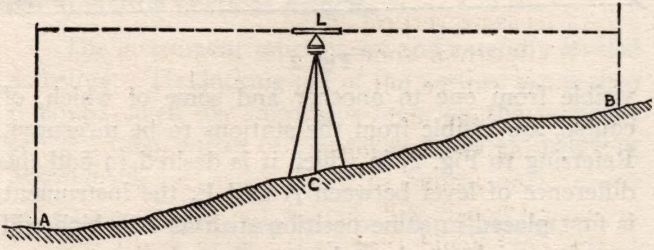


Fig. 1

to be measured. Hold the rod at A, obtain height of target corresponding with cross line in telescope or sight tube, and record in note book. Then carry the rod to B and obtain height of target at that point. The

difference between the two heights as read on the rod will be the difference of level of the two places—that place being higher at which the height of target is less.

Sometimes the two places are not visible from each other, or differ considerably in level. In this case the operation is similar, but requires several sets of readings, connecting various points which are

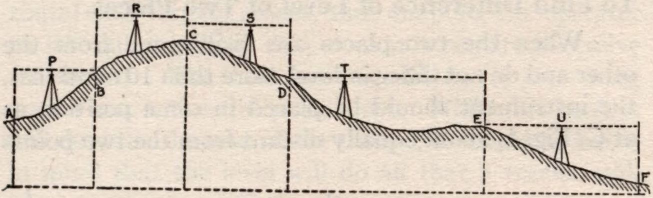


Fig. 2

visible from one to another and some of which, of course, are visible from the stations to be measured. Referring to Fig. 2, in which it is desired to find the difference of level between A and F, the instrument is first placed in some position such as P, which will permit a sight to be taken to A and also to some other point, B, in the general direction of F and about as far from the instrument as A. Having leveled the instrument, obtain the height of target at A, and record it in note book as a first "back-sight." The reading of the target at B will be noted as the first "fore-sight."

The instrument is then taken to some place such as R, being moved again towards F, while the rod is still held at B. From R, a back-sight is taken on B and a fore-sight on another point, C, still nearer to F. In the same manner the operation is continued from one point to another, until the station F is reached with the final fore-sight. Then the difference between the sum of the back-sights and the sum of the fore-sights will be the difference of level between A and F. If the sum of the back-sights is greater than that of the fore-sights, F is higher than A; if the sum of the back-sights is less than the sum of the fore-sights, F is lower than A.

To Measure Vertical Angles.

The instrument must be set and carefully leveled as before. The locking pin of the vertical arc is then removed when, by raising or lowering the telescope or sight tube, angles can be taken up to 45° below or above level.

To Lay Out Building Lots or Foundations.

By means of a plumb bob suspended from the hook under the tripod head, the center of the instrument is set directly over the station mark or corner of the lot or building to be laid out. The instrument is then carefully leveled as before, after which neither

the hands nor the coat of the operator should be allowed to touch the legs of the instrument.

If A B in Fig. 3 represents the street line and the corner of the proposed building is set at C, which is distant from the street line, N C, then a distance O P equal to N C should be measured from the street line at some point O which is at least as far from N

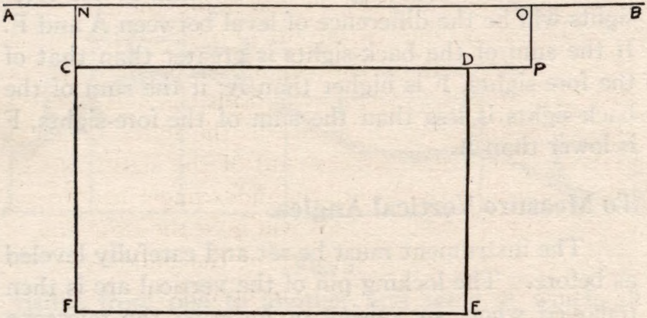


Fig. 3

as the length of the proposed building. Set a stake at P, then the line C P will be parallel with the street. A distance from C in the straight line toward P is next laid off, equal in length to the building or lot; this determines the two front corners C and D.

To get the line at right angles to C D, leave the sights still directed on the stake at P and the sight tube clamped by means of the clamp screw and nut.

Then turn the graduated arc until the index finger can be pressed into the zero mark by means of the push pin. Screw the graduated arc in that position by the clamping lever. Then turn the eye end of the sight tube or telescope to the left until it has turned a right-angle, or 90°. A sight along its new position will give the line C F, on which the required distance is measured off to determine the corner F.

Next move the transit to D and level it up as before. Direct the sights to a rod or nail on the stake at corner C. Clamp the transit in this position and bring the zero of the arc to the index finger as before. Then turn the eye end of the sight tube or telescope to the right until the index finger has turned a right angle, or 90°. This will give the direction of D E, on which line the width of the building or lot will be measured off, thus determining the corner E.

To prove the work and make sure that no errors have occurred, the transit should then be set up at E and operated the same as when at D. If the sights strike the stake at F and if the distance E F equals the distance C D the work is proved correct. If either of these fail an error has been made, either in the measurements or in turning the angles. In this case the work must be repeated until it checks with itself.

Where the outline of the building is other than a rectangle, the procedure is just the same from one

point to the next, but more points have to be arranged for, and the final proving of the work is more likely to reveal a small error. It is usually advisable with

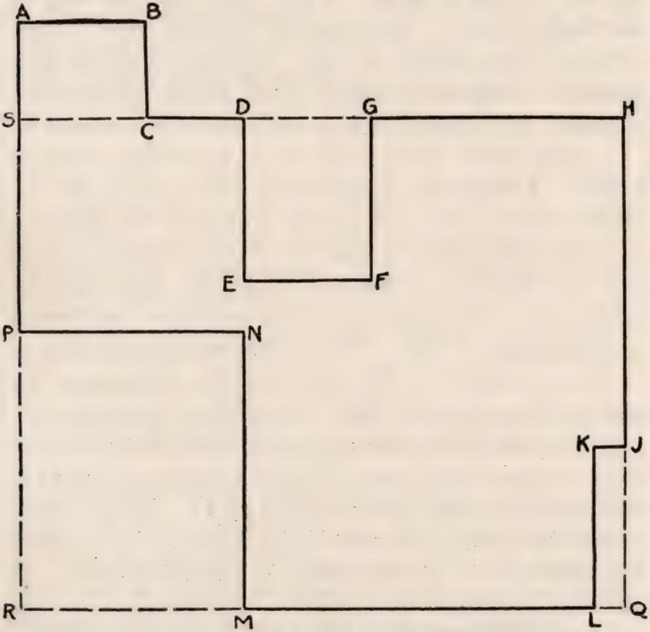


Fig. 4

an irregular shaped building, such as shown in Fig. 4, to lay out first a large rectangle which will comprise the entire building or the greater part of it. This is

shown in Fig. 4 as the rectangle H Q R S. Having this once established accurately, the remaining portion of the layout will consist in small rectangles, each of which can be laid out by itself and proved separately. As will be noted in the figure, these rectangles are respectively JKLQ; MNPR; ABCS and DEFG. This happens to be the layout of a brick house built a great many years ago, before modern ideas of compactness were in vogue.

It recently became necessary to divide into three equal parts a plot of land such as is shown by solid lines in Fig. 5. The sides A B and A D run along streets intersecting at an acute angle. The measurements and bearings of the four lines bounding the area were as follows:

A B	412′	N.	76° E.
B C	219′ 4″	N.	33° 10′ W.
C D	276′	S.	62° W.
D A	158′	S.	13° W.

The two lines of division were required to be perpendicular to the street line A B.

The first thing was to find the area of the plot. This can be done in either one of two ways: — Surround the area with a rectangle, A N P Q, all of the sides of which run with the points of the compass. Find the measurements of the rectangle; of each of the four triangles, ABN, BCP, CDS and ADT; also

of the rectangle TDSQ. The difference between the area of the large rectangle and the five smaller areas mentioned will give the total area of the plot.

A simpler method, however, is shown in Fig. 6, in which the bearing of the several lines with regard to the points of the compass are disregarded. By

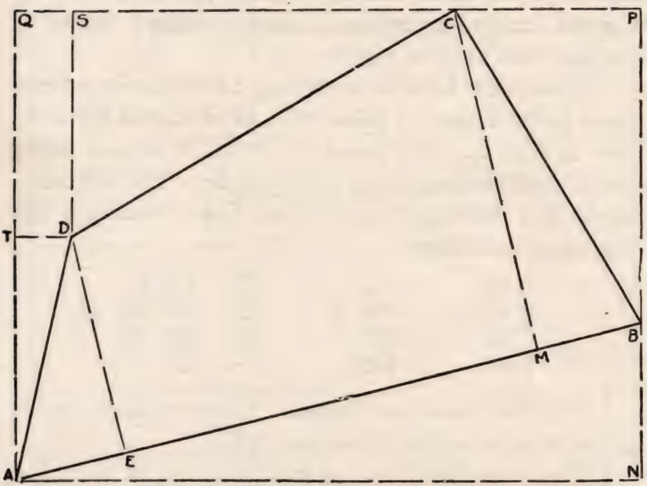


Fig. 5

analyzing the bearings already given it may be shown that the angle at A is 63°, while that at B is 70° 50′. Knowing the distances A D and C B, it is perfectly easy by means of trigonometry*, to obtain the distances

A E, E D, B M and M C. Having obtained these dimensions it is evident that the area of each of the two triangles ADE and BCM will be equal to half the product of its two sides which meet at right angles. Thus, $ADE = 1/2 AE \times ED$, and $MCB = 1/2 CM \times MB$. Then the area CDEM, which is a trapezoid, will be equal to the product of the height, EM, by half the sum of the bases, DE and CM. Adding together

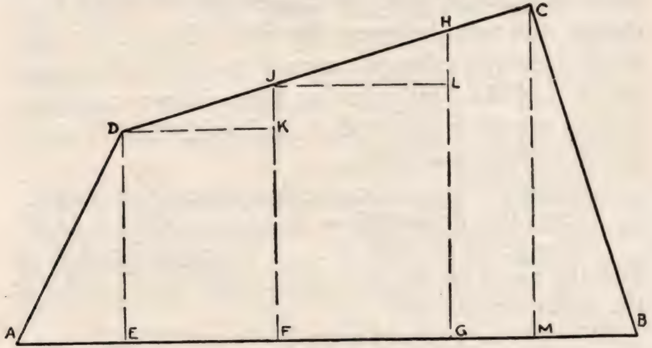


Fig. 6

the area of the trapezoid and those of the two triangles we have the entire area, 59,177 square feet, of which each " share " will be 19,726 square feet.

As we already have the area of the triangle ADE (5,049 square feet), it follows that the area of DEFJ,

*See page 22, for elementary principles of trigonometry, giving methods for obtaining such results as will be found necessary.

or the balance of the first lot, will be 14,677 square feet. It now remains to find the point F, from which the perpendicular line will be set off to bound this lot.

Suppose the line D K drawn parallel to A B; then the area required will be equal to $DE \times EF + 1/2\ JK \times DK$. But $DK = EF$; $\therefore$ $DEFJ = EF \times DE + 1/2\ EF \times JK = 14{,}677$. DE has been found to be 140.78 feet. JK = EF tangent 14° (the angle JDK is 14° and the tangent of the angle is, of course, the ratio between the side J K and the side DK). From a table of tangents we find that tangent 14° = 0.24933. Substituting these known quantities in our equation we find that $EF \times 140.78 + 1/2\ (EF)^2 \times 0.24933 = 14677$.

Solving this equation we find that EF = 96.13′.

From this we get JK = 96.13 × 0.24933 = 23.97′.

Now to prove that F is at the right location we find the areas of the two figures between E and J in the usual manner :—

EF×ED = 96.13×140.78 =	13,533	square feet.
DKJ = 1/2×96.13×23.97 =	1,144	"
	14,677	"

The location of point G, setting off the second division line GH, is found in the same manner except that the area FGHJ is, of course, the entire 19,726 square feet. The distance FG is found to be 110.5 feet.

Another simple method of obtaining the same result by means of the transit may be used. Set the

instrument at D with the plumb bob directly over the station mark or corner of the plot. The instrument should then be carefully leveled as before.

Sight to a rod or stake at A. Clamp the sight tube by means of the clamp screw and nut. Then turn the graduated arc until the index finger can be pressed into the zero mark by means of the push pin. Screw the graduated arc into that position by the clamp lever. Then move the eye end of the sight tube or telescope to the left until it has turned through an angle of 27° (to make a right angle at E, the sum of the angles at A and D of the triangle A D E must equal 90°; as A is 63° the angle at D must be 27°). Drive a stake at E, directly in line with the new sight and on the line AB. Then the line ED will be perpendicular to AB. In a similar manner, by making the small angle at C equal 19° 10′ the point M is obtained. Measure AE, ED, MB and MC.

The area of the plot will be the sum of the areas of the two triangles ADE and BCM added to the area of the trapezoid CDEM. We now know all of the dimensions of these three figures and can easily obtain the area. It is found that AE is 71′ 9″, ED is 140′ 9″, MB is 72′ 1/4″ and MC, 207′ 2″. Now, the area of a right angle triangle is equal to one-half the product of the two sides meeting at right angles.

Hence, $ADE = 1/2 \times 71.75 \times 140.75 = 5049$ square

feet. Similarly, the other triangle is 7,459 square feet. The area of the trapezoid will be equal to the product of the height, EM, multiplied by one-half the sum of the bases, ED and MC. Thus the area is :—
$1/2 \times 268.25 \times (140.75 + 207.17) = 46{,}669$ square feet. The total area is therefore 59,177 square feet and each one of the three equal shares is 19,726 square feet.

The first plot will include the triangle ADE plus the trapezoid DEFJ. We do not know the distance EF or the distance FJ. We do know that the angle JDK is 14°, and in a table of angles the ratio of JK : DK for 14° is 0.24933; that is, $JK = 0.24933 \times DK$. Also, the area of the trapezoid will be equal to $19{,}726 - 5{,}049 = 14{,}677$ square feet. This makes an equation which can be readily solved by algebra, giving the dimension DK=96′ 1 1/2″. By using the ratio between JK and DK we find that JK is 23′ 11 1/2″, hence, FJ is 164′ 8 1/2″. In the same manner the distance FG may be found such that the area FGHJ will equal 19,726 square feet. In this case we will remember, of course, that LH equals $0.24933 \times JL$ and obtain our result as before. In this way FG is found to be 110′ 6″.

Having obtained all the dimensions shown on the sketch it is advisable always to check the result in order to make sure that no errors have occurred. For instance, knowing FG, FJ and GH we know that the

area of the middle one of the three equal plots (19,726 square feet) must equal 1/2 FG$\times$(FJ + GH). By making the actual multiplication we find that the area checks with the required area almost exactly.

To Find Irregular Areas.

It may become necessary to find the *area of a pond* of irregular shape, such as shown in Fig. 7. In this

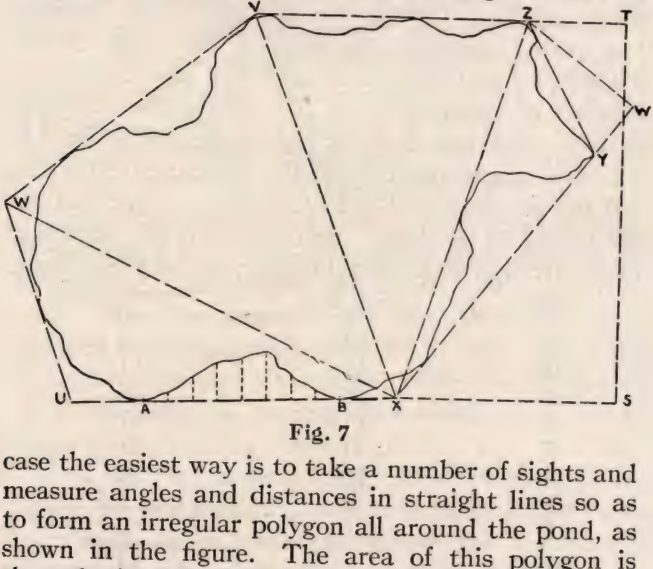


Fig. 7

case the easiest way is to take a number of sights and measure angles and distances in straight lines so as to form an irregular polygon all around the pond, as shown in the figure. The area of this polygon is then obtained in the same manner as in the last example. There will be a number of places where the

land juts out into the pond. The areas of all these portions must be deducted from the area of the polygon in order to get the net area or water surface of the pond. The method of treatment is shown near the lower left corner of the drawing, where one of these areas has been subdivided by lines perpendicular to our polygon line, and running from that line to the water's edge. Taking the distance, AB, between two points touching the edge of the pond, this is measured and then sub-divided into any convenient number of parts (8, 9 or 10). From the points of division, offsets are taken at right angles to the line AB.

Let us suppose that in the present case the line AB has a length of 120 feet, and that eight sections are taken, 15 feet long. Setting down the lengths of offsets from these stations in order, we have as follows:

Station	Offset (feet)	Corrected Offset
A	0	0
1	4	4.4
2	11	11
3	16	16
4	17	17
5	21	21
6	10	10
7	5	5.5
B	0	0
Sum		84.9
Interval between stations		15
Area of plot		1,273.5

This method of finding irregular areas by offsets is a very simple one. The rule may be stated as follows: Add together all of the offsets or ordinates; add 0.1 of the second ordinates from each end; deduct 0.6 of the end ordinates; multiply the result by the distance between ordinates. This will give very close results— much closer, of course, with a large number of ordinates than with a small number, but in a case like the present, 8 or 10 will usually be found sufficient.

Another method of finding the area of our irregular polygon around the pond may be given; in which we make use of the areas of a series of triangles which make up the total area. For instance, the triangle X Y Z has two sides known, X Y and Y Z. They are not, however, at right angles to each other. If we extend the side X Y to some point, such as W, where the transit shows the angle XWZ is a right angle, then by measuring the line ZW we have an altitude of triangle with base XY. The area of this triangle will be 1/2 XY $\times$ ZW. In a similar manner all of the triangles making up the total area can be figured and the area found.

In the case of the triangle XZV, where all of the angles are less than 90°, and the altitude would therefore have to be measured across the water, this altitude may be obtained by extending VZ to some point T, and drawing from X a line parallel to VZ to

some point S, such that it may be possible to measure a line from T to S (which line will be perpendicular to VZ and also to XS). Then the line TS will be the altitude of a triangle with base VZ. Of course, the line XS is made parallel with VZ by making the angle ZXS, measured by the transit at X, equal to angle XZV, measured at Z. This is easily done by means of the instrument, which is also used for getting the right angle at T.

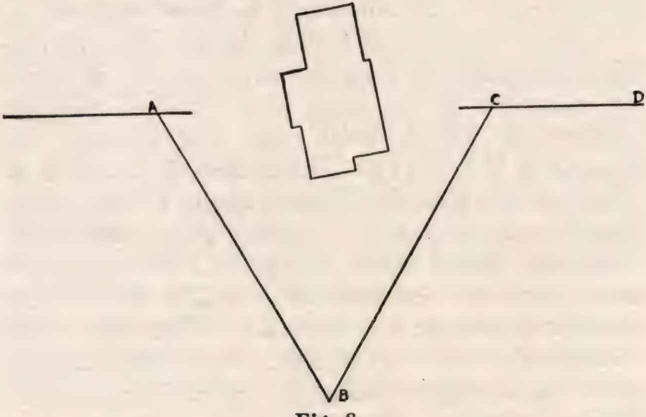


Fig. 8

If in running a line *an obstacle* is encountered, such as a house or barn, which cannot be crossed but can be avoided by going to the right or left, it is easy to continue the original line on the side of the obstacle in the following manner: — Referring to

Fig. 8, and assuming that the line is taking the general direction AC and has reached the point A, run a line from A to some point B, making the acute angle at A 60°, then set the instrument at B and make another acute angle of 60° in the direction of C. By making the distance BC equal the distance AB, C will be directly in the original line, and the distance AC will equal the distance AB, which has already been measured. By making the acute angle at C again 60°, the line CD will be in the original direction.

To Measure Across Water.

If it becomes necessary to measure a distance across water, such as a stream or pond, Fig. 9, this is done as follows : — If the distance AB is wanted, set the instrument at B and direct it so as to make a right angle ABC. Measure off on BC any convenient distance (preferably not less than half the estimated distance AB). Set the instrument at C and make a right-angle A C D such that the point D will fall on both the line C D and A B extended. Then we have a proportion A B : B C as B C : B D, from which $A\,B = \frac{(B\,C)^2}{B\,D}$. If B C is 300 feet, and B D is found to be 200 feet, then $A\,B = \frac{300 \times 300}{200} = 450$ feet.

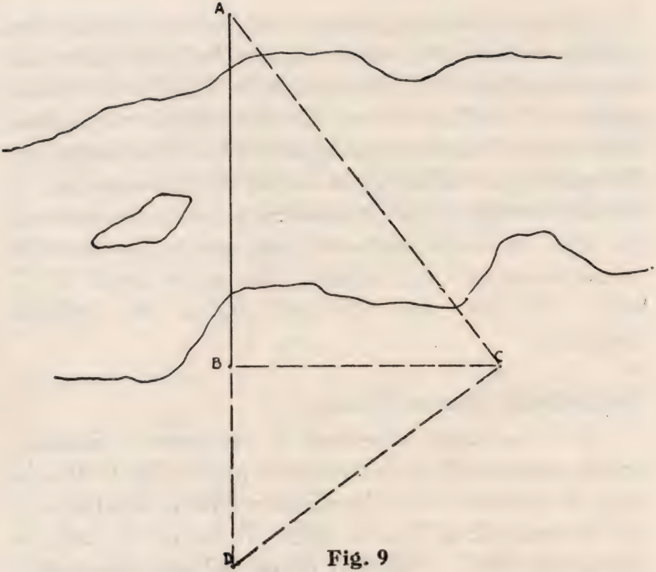


Fig. 9

Notes on Trigonometry.

In any right angle triangle, such as ABC, Fig. 10, the relations of the three sides one to another are given different names as referring to the angles. For instance, considering the angle A, the ratio of a/c is called the sine, and is written sinA. The ratio b/c is called the co-sine and is written cosA. The ratio a/b is called the tangent and is written tanA. The ratio b/a is called the co-tangent and is written cotA. There are other relations which do not here concern us.

No matter what the size of the triangle, the sine of 20° or any other definite angle is always a definite amount, corresponding with that angle. The same holds true with regard to the other functions, as they are called. This also holds true not only with regard to the triangle in Fig. 10, but also with regard to the

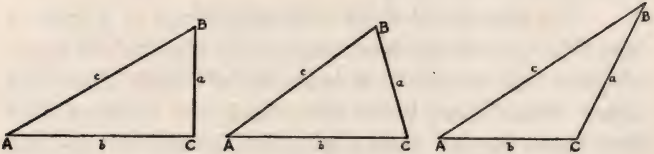


Fig. 10 **Fig. 11** **Fig. 12**

oblique triangles in Figs. 11 and 12; but in the case of the oblique triangles the sine and other functions will, of course, not be represented directly by the several sides of the triangle. A table of the sines, co-sines, tangents and co-tangents for angles from zero to 45° is given on page 26. At the bottom of each column will be found the same list of functions in a different order, which might be explained by the fact that the sine of any angle X is equal to the co-sine of (90° — X). Similarly, the $\tan X = \cot (90° - X)$. It is thus evident for angles between 45° and 90° the tables are to be read from bottom upwards, and the angle index is that shown at the right instead of at the left. Thus the sine of 56° is .82903.

For obtuse angles, such as that at C, Fig. 13, the relations are somewhat different, as follows :—

$$\sin C = \sin(180° - C). \quad \cos C = -\cos(180° - C).$$
$$\tan C = -\tan(180° - C).$$

With this explanation, the sine, co-sine, tangent and co-tangent of any angle in a triangle can be determined readily from the table.

The lengths of sides and magnitude of angles of any triangle can be determined very easily if we know three of the six items, at least one of which must be a side. Thus, if we know the side *b*, the angle A, and the angle B, the side *a* may be determined by the formula $\frac{a}{b} = \frac{\sin A}{\sin B}$. Having two angles of a triangle, whether it is a right triangle or not, we immediately know the third angle to be the difference between 180° and the sum of the first two angles. Thus $C = 180° - (A+B)$. Having thus found C we find *c* by the formula $\frac{c}{a} = \frac{\sin C}{\sin A}$.

Referring specifically to Fig. 6:

A E = A D cos 63° = 158 × 0.45399 = 71.73 feet
D E = A D sin 63° = 158 × 0.89101 = 140.78 feet
Area A D E = 1/2 × 71.73 × 140.78 = 5049 square feet

In a similar manner M B is found to be 68.17 feet; M C is 221.14 feet and area M C B is 7,538 square feet.

In case the three items we know are two of the sides and the angle between them, such as *b*,*c*, and A,

the value of *a* is found from the formula:

$$a^2 = b^2 + c^2 - 2\ bc \cos A.$$

Having three sides and one angle it is perfectly easy to find the other two angles by the formula already given.

The area of any triangle is equal to half the product of two sides by the sine of the angle between them. Thus

$$\text{Area} = 1/2\ ab \sin C,\ 1/2\ bc \sin A, \text{ etc.}$$

With the use of these formulas and the tables any of the ordinary problems liable to come up in connection with the laying out of drains, foundations, fields, etc., or the measurement of areas comprised within such lines may be accomplished with very little labor.

It frequently becomes necessary to use a function of some angle which is not expressed in even degrees. For instance, in connection with Fig. 6 we had occasion to use the sine of 70° 50′ and the co-sine of the same angle. We here illustrate the method of obtaining these figures from the table on page 26.

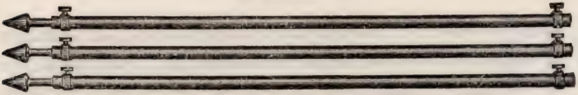
$$\begin{array}{ll}
\text{Sin } 71° = \ .94552 & \text{Cos } 70° = \ .34202 \\
\text{Sin } 70° = \ .93969 & \text{Cos } 71° = \ .32557 \\
\text{Difference} = .00583 & \text{Difference} = .01645 \\
\frac{50}{60} \times .00583 = .00480 & \frac{50}{60} \times .01645 = .01371 \\
\therefore \text{Sin } 70°\ 50' = .94449 & \therefore \text{Cos } 70°\ 50' = .32831
\end{array}$$

In a similar manner, the tangent of 28 1/2°, or 28° 30′, will be half way between the tangents of 28° and 29°, or .54301. Likewise, tangent 28° 45′ will be .54866, etc.

o	Sine	Tang.	Cotan.	Cosine	o
0	.00000	.00000	Infinite	1.0000	90
1	.01745	.01745	57.290	.99985	89
2	.03490	.03492	28.636	.99939	88
3	.05234	.05241	19.081	.99863	87
4	.06976	.06993	14.301	.99756	86
5	.08716	.08749	11.430	.99619	85
6	.10453	.10510	9.5144	.99452	84
7	.12187	.12278	8.1443	.99255	83
8	.13917	.14054	7.1154	.99027	82
9	.15643	.15838	6.3138	.98769	81
10	.17365	.17633	5.6713	.98481	80
11	.19081	.19438	5.1446	.98163	79
12	.20791	.21256	4.7046	.97815	78
13	.22495	.23087	4.3315	.97437	77
14	.24192	.24933	4.0108	.97030	76
15	.25882	.26795	3.7320	.96593	75
16	.27564	.28674	3.4874	.96126	74
17	.29237	.30573	3.2709	.95630	73
18	.30902	.32492	3.0777	.95106	72
19	.32557	.34433	2.9042	.94552	71
20	.34202	.36397	2.7475	.93969	70
21	.35837	.38386	2.6051	.93358	69
22	.37461	.40403	2.4751	.92718	68
23	.39073	.42447	2.3559	.92050	67
24	.40674	.44523	2.2460	.91355	66
25	.42262	.46631	2.1445	.90631	65
26	.43837	.48773	2.0503	.89879	64
27	.45399	.50952	1.9626	.89101	63
28	.46947	.53171	1.8807	.88295	62
29	.48481	.55431	1.8040	.87462	61
30	.50000	.57735	1.7320	.86603	60
31	.51504	.60086	1.6643	.85717	59
32	.52992	.62487	1.6003	.84805	58
33	.54464	.64941	1.5399	.83867	57
34	.55919	.67451	1.4826	.82904	56
35	.57358	.70021	1.4281	.81915	55
36	.58779	.72654	1.3764	.80902	54
37	.60181	.75355	1.3270	.79864	53
38	.61566	.78129	1.2799	.78801	52
39	.62932	.80978	1.2349	.77715	51
40	.64279	.83910	1.1918	.76604	50
41	.65606	.86929	1.1504	.75471	49
42	.66913	.90040	1.1106	.74314	48
43	.68200	.93251	1.0724	.73135	47
44	.69466	.96569	1.0355	.71934	46
45	.70711	1.0000	1.0000	.70711	45
	Cosine	Cotan.	Tang.	Sine	o

Leveling Instrument No. 101

No.101



It should be borne in mind that our leveling instruments do all that a transit will do except measure vertical angles. These instruments attain angles in a horizontal plane only, and are designed for the use of farmers, contractors, carpenters, millwrights, masons, surveyors, etc.

Its lightness, simple construction, and moderate price, combined with the wide range of work to which it can be applied, make it very desirable for all who have occasion to use such an instrument. The upper plate is connected to the tripod head by a ball and socket joint, and is leveled by the leveling screws. This plate is recessed to contain a graduated arc for taking angles, and on the plate is the frame with level and sight tube for taking horizontal angles only.

The PLAIN SIGHT TUBE has no lenses, is brass, nickel plated, twelve inches long; in one end is a small eye aperture, in the other the usual cross wires.

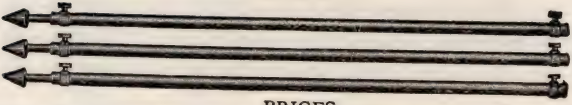
The TELESCOPE has cross lines, is adjustable to distances, and is same size and length as plain sight tube. The lense is well protected from dirt and breakage by a friction cap, and a shutter for the eye aperture.

PRICES

No. 101 A With plain sight tube, long legs and plain level vial....... **$15.00**
No. 101 B With plain sight tube, long legs and ground level vial **16.75**
No. 101 C, With telescope, long legs and ground level vial....... 25.00

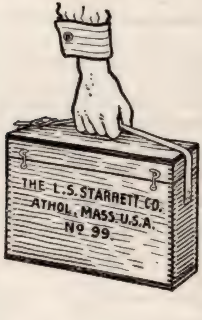
Starrett Transit No. 99

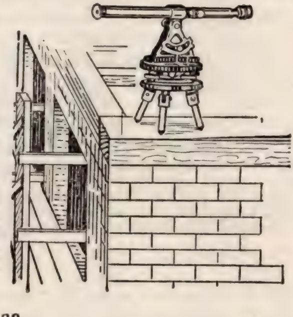
No.99



PRICES

No. 99 B	With plain sight tube, long legs and plain level vial	$20.00
No. 99 F	With telescope, long legs, and ground level vial	40.00
Iron target to go on pole, extra		1.50





Transit No. 99

The instrument is composed of iron and brass, and consists of a tripod, to the head of which is connected by a ball-and-socket joint an upper plate, which can be levelled by the leveling screws.

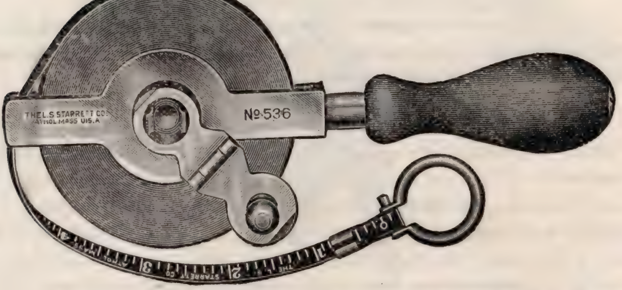
This plate is recessed to contain a graduated arc for taking horizontal angles. This arc is ½ of a circumference, reading 90° each side of 0, and being independent of level and sight tube can be turned and used at any point of a complete circle. On this plate rests a triangular frame to which are attached a level, a graduated arc for taking vertical angles, graduated 45° each side of 0, and a sight tube. The PLAIN SIGHT TUBE has no lenses, is brass, twelve inches long; in one end is a small eye aperture, in the other the usual cross wires.

The TELESCOPE has cross lines, is adjustable to distances, and is same size and length as plain sight tube. The lens is well protected from dirt and breakage by a friction cap, and a shutter for the eye aperture.

With short legs, as shown in the cut, the instrument is eight inches high. With long extension legs, which fasten on over the short legs, the height can be from two feet eight inches to four feet eight inches. The sight tube, level case and graduated arcs are nickel plated, the other parts are japanned.

The advantages of this transit are as follows: The head is held to the tripod with a bolt and knurled nut, so as to make it stationary at any given point; the graduated arc can be clamped to the base-plate by throwing a small cam arrangement, and a spring indexing finger to mesh in the arc graduations. The transit with short legs is housed in a substantial wood box about 4¾ inches x 9½ inches x 13¾ inches; with a leather strap running completely over the box cover, weighing approximately 8 lbs., making it easily carried about. The extension legs are not packed in the box. They weigh about 6 lbs., so when used with the short legs the transit weighs about 11 lbs.

Starrett Steel Tapes

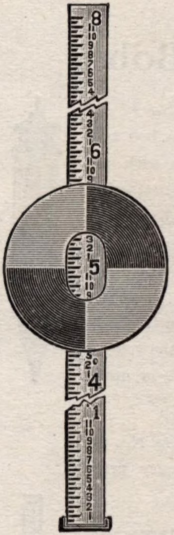


To lay off desired distances accurately along lines determined by the transit and level, it is necessary to have some standard which is long enough for rapid work, yet sufficiently compact to be readily portable. These qualifications are met by our line of steel tapes, which are made in a large variety of styles, in different lengths up to 100 feet, and are graduated in convenient units. They are made with leather and with nickel plated steel cases or are mounted on reels. These reel tapes are for the particular convenience of those men who must make frequent measurements of considerable distances. The handle of the reel permits rapid winding and rewinding.

Starrett steel tapes may be depended upon absolutely for accuracy.

Our line now includes STAINLESS STEEL tapes, a distinct advance in this field.

A special steel tape booklet will be sent free on request.



Wood Leveling Rod and Target

For Use With Transits and Leveling Instruments

Made of seasoned stock. The rod has two 4-ft. sections, which can be easily and quickly aligned by a positive locking arrangement, making a total height of 8 feet. The bottom of the rod is steel capped.

Divided into feet, inches, and quarter inches (see cut) with heavy lines and figures; the foot figures red and the inch figures black.

Approximate weight, 1¼ lbs.

Price, Rod and Target, $5.00

Tape Hooks No. 514

For Attaching to Steel Tapes

These hooks are made from brass castings and are nickel plated. They are easily attached to our ¼-inch or ⅜-inch tapes, and are designed to take measurements from the inside of the hook.

Starrett Plumb Bobs

Our improved mercury plumb bobs No. 87 are much superior to the ordinary cast iron bob and are recommended for use in connection with our transits or leveling instruments and steel measuring tapes. They are made from solid steel, bored and filled with mercury, and are nickel-plated. Noteworthy features are their great weight in proportion to size, low center of gravity, small diameter, hardened and ground points, knurling on the body and the simple and effective device at the top for fastening the line without a knot to tie or untie. Made in four sizes.

Plumb bobs No. 177, same design as No. 87, but made from solid steel, the mercury being omitted.

Plumb bobs for attaching to steel tapes, used for gaging oil in tanks, etc. No. 515-A, cast iron, japanned finish — No. 515-B, solid steel, nickel-plated.

Complete catalog of Fine Tools, Hacksaws, and Steel Tapes sent free on request.

No. 515A

No. 515B

THE L. S. STARRETT CO.
ATHOL, MASS.